Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	
Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37, and	ET Docket No. 14-165
Amendment of Part 74 of the Commission's Rules for Low Power Auxiliary Stations in the Repurposed 600 MHz Band and 600 MHz Duplex Gap	
Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions	GN Docket No. 12-268

GOOGLE INC. PETITION FOR RECONSIDERATION

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I. INTRODUCTION AND SUMMARY.

The Commission's Part 15 Order will advance the goal of improving wireless broadband while protecting incumbent licensees from harmful interference. Two particular aspects of the order, however, undermine this overall benefit and should be reconsidered.

First, the Commission should correct the consequences of a technical misapprehension that led it to require databases to "push" channel-availability information to unlicensed devices. The Commission correctly recognized that requiring devices to "pull" information from databases at rapid intervals would create unreasonable operational burdens on databases and devices and appropriately declined to establish such a rule. But the Commission did not provide adequate notice that it was considering a "push" mandate in the alternative and, accordingly, was unaware that a "push" mandate has the same disqualifying problems, and to an even greater degree.

Second, to avoid delay by resistant medical telemetry users, the Commission should reconsider and clarify the purpose and timeline for Channel 37 test deployments, including establishing a target date for nationwide roll-out of unlicensed operations in Channel 37.

II. THE COMMISSION ERRED IN REQUIRING DATABASES TO "PUSH" WIRELESS MICROPHONE RESERVATION INFORMATION TO UNLICENSED DEVICES.

The Commission correctly recognized in the Part 15 Order that its initial proposal to require all unlicensed devices to recheck a TV white space database every 20 minutes would unnecessarily and substantially burden database operators and unlicensed devices. If required several times each hour, mandatory queries to "pull" any available information would greatly increase the cost of operating white space databases and reduce the battery life of white space

devices.[1] The Commission therefore properly rejected its own initial proposal. In its place, however, the Commission adopted an even more flawed requirement "that database administrators 'push' information to white space devices in the area where the licensed wireless microphones will be used, notifying them of changes in channel availability."[2]

Adopted without prior public notice, this decision relies on the faulty assumption that having databases "push" information to unlicensed devices in specified geographic areas would be less burdensome than having all unlicensed devices recheck or "pull" information from a database. Not only is the local "push" requirement at least as burdensome as a general "pull" approach, but also it will not be feasible for database operators to "push" information to all categories of unlicensed devices. The Commission therefore should reconsider this decision and instead adopt the "fast-polling" channels solution proposed by Google and supported by other commenters.

A. The Commission correctly rejected its 20-minute recheck proposal, but failed to recognize that requiring databases to "push" information to devices is at least as burdensome as requiring devices to "pull" information from databases.

In the Part 15 Order, the Commission correctly recognized that requiring all unlicensed devices to query a database every 20 minutes would create significant burdens on unlicensed users and database operators, and go beyond what is necessary to protect wireless microphone

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1 Comments of Google Inc. at 47-48, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) ("Google Comments").

2 *Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37, and Amendment of Part 74 of the Commission's Rules for Low Power Auxiliary Stations in the Repurposed 600 MHz Band and 600 MHz Duplex Gap; Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Report and Order, 30 FCC Rcd. 9551, 9662 ¶ 273 (2015) ("Part 15 Order").

users during breaking news events.[3] The Commission noted record evidence that, as compared to the current 24-hour polling rule, a 20-minute recheck requirement "would be a 72 times increase in daily polling of the databases by each white space device in use, thus increasing the costs for managing the databases . . . and decreasing the battery life of white space devices."[4] The Commission rightly found that a 20-minute recheck requirement imposed on all devices would

> unnecessarily burden the white space databases, drive up costs for database management and white space devices users, and is overly-broad in satisfying the objective of the original proposal, *i.e.*, to ensure that white space devices clear a channel needed for licensed wireless microphone users for late-breaking events in a specific area.[5]

Instead, the Commission adopted a requirement that "database administrators 'push' information to white space devices in the area where . . . licensed wireless microphones will be used, notifying them of changes in channel availability."[6] The Commission believed that a "push" requirement would "balance[] the needs of both white space device and wireless microphone proponents" by "mak[ing] spectrum available for licensed wireless microphone use for late-breaking events, [without] burden[ing] all white space users with unnecessary frequent database re-checking."[7]

The decision to require databases to "push" wireless microphone reservation information to unlicensed devices thus assumes (without record support) that there is a meaningful technical difference between, on the one hand, "pushing" information out to devices and, on the other,

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3 *Id.* at 9663 ¶ 277.

4 *Id.* at 9663 ¶ 275.

5 *Id.* at 9663 ¶ 277.

6 *Id.* at 9662 ¶ 273.

7 *Id.*

having devices query a database to "pull" reservation information. In practice, there is no meaningful difference between the two approaches, and the "push" mandate imposes the same or greater burdens on unlicensed devices and database operators. Moreover, although the Commission intended to limit the burden on unlicensed devices and databases by restricting the "push" requirement to geographic locations near where a wireless microphone has reserved spectrum, practical implementation of this requirement will mean that all unlicensed devices, regardless of location, must listen for communications from the database.

As discussed in the attached declaration of Andy Lee, technical lead for Google's Spectrum Database program, in order for a database to communicate information to an unlicensed device, that device must either request information very frequently in order to simulate a "push," or maintain a persistent connection with the database.[8] Without frequent "pulls" from the database or a persistent, open connection, security features implemented on the device or network may block database messages. For example, some devices operate behind proxies, behind routers that use Network Address Translation ("NAT") to assign devices non-routable IP addresses, or on secure networks that restrict certain inbound connections.[9] In any of these three scenarios, the proxy, router, or secure network settings could prevent the delivery of a "push" notification from the database unless the device itself frequently requests information from the database or maintains a persistent connection.[10] If an unlicensed device does not frequently poll the database or loses its persistent connection, then it may not receive information from the database.

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8 Declaration of Andy Lee ¶¶ 7, 9 (attached).

9 *See id.* ¶¶ 5-6.

10 *Id.*

Inevitably, achieving the appearance of a database "push" by requiring devices to query their database very frequently suffers from all the same drawbacks that the FCC identified when it rejected the 20-minute recheck proposal. Frequent polling of a database by white space devices would dramatically increase database server utilization (possibly increasing database fees for users) and reduce the battery life of unlicensed devices. The more the desired implementation looks like a "push," the more frequently a device must pull information from the database.

Alternatively, to maintain a persistent connection, an unlicensed device must periodically send "keep-alive" messages so that neither the server nor client closes the connection.[11] Sending these regular "keep-alive" messages would both use scarce bandwidth and reduce battery life, particularly because sending regular messages prevents a device from sleeping, a method often used to conserve battery.[12] Moreover, requiring the database server to maintain persistent open connections with potentially millions of individual unlicensed devices would require significant server resources, likely more than what would be required to implement the 20-minute recheck requirement the Commission already deemed unacceptable.[13] Therefore, both the "push" and "pull" approaches would impose similar and significant burdens on unlicensed users and database operations,[14] eliminating the stated justification for the rule adopted by the Commission.

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[11] *Id.* ¶¶ 10-11.

[12] *Id.* ¶ 14.

[13] *See id.* ¶¶ 12-14, 17.

[14] *Id.* ¶¶ 16-18. In theory, a push notification to a white space device would work in the same way as push notifications to smartphones and tablets. Push notifications to a smartphone also require a persistent connection to the server authorized to send the pushes. However, there are constraints in the white spaces context not applicable to smartphones and tablets. First, smartphones and tablets are designed to be charged regularly, while some unlicensed

The Commission intended to limit the burden associated with the "push" rule by requiring databases to "push" notifications only to devices located in geographic proximity to the wireless microphone reservation.[15] Limiting the geographic area for database "pushes," however, does not reduce the burden on unlicensed devices or databases. Because there is no way for a database to communicate information to a device without that device frequently querying or maintaining a persistent connection to the database, all devices in all locations would need to check continually for database updates, even if the database ultimately delivers information only to a limited subset of devices near where a licensed wireless microphone has made a reservation.[16]

In practice, the "push" rule also would dramatically limit the use of some white space devices. As noted above, implementing a "push" would require either very frequent database polling or maintaining a persistent connection, significantly draining device battery life. Battery life constraints would hamper innovation in certain use cases or industries that would otherwise be technically viable. For instance, battery powered low-bandwidth, or remote devices such as

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devices—like smart meters or security monitoring systems—may be expected to go months without charging. The battery-life tradeoffs to maintain a persistent connection are more costly for such devices. In fact, while smartphone and tablet users may be able to disable push notifications as a means of conserving battery power, no such option would be available to other white space devices. Second, push notifications to smartphones and tablets typically are offered on applications that do not require as high a level of reliability or timeliness as required in this context. Achieving the necessary level of reliability in the white spaces context would require additional background communications to verify that all messages were properly received.

[15] *See* Part 15 Order at 9662 ¶ 274 ("The database administrators need to push this information only to white space devices that are located within the separation distances, specified in rule section 15.712(f)(1), from the location specified by the wireless microphone registrant.").

[16] Declaration of Andy Lee ¶ 19.

sensors, meters, or security systems typically designed to operate for very long periods on a single battery charge likely could not be deployed in the restricted spectrum.

B. The "push" approach was not identified in the NPRM and did not receive adequate record discussion.

The Commission did not seek comment in the Notice of Proposed Rule Making ("NPRM") on whether to require database operators to "push" information to unlicensed devices. Instead, the Commission proposed to protect licensed wireless microphone operations during breaking news events by requiring all white space devices to query the database every 20 minutes. The suggestion that database operators could "push" information to unlicensed devices appears to have come from one-line mentions of "push" technology in comments by the Wireless Internet Service Providers Association ("WISPA") and the White Space Alliance ("WSA").[17] WSA suggested, without support, that "push technology whereby[] the database actively pushes information back to the WSDs would be far more efficient [than a 20-minute recheck requirement] and could provide sub-second response times."[18] WISPA similarly stated, again without support, that it would be "much more spectrally efficient and network-resource efficient for a white space database simply to push a notification of the need for a frequency change to a specific white space base station or node if and only if a frequency change is actually necessary. The database should be configured to incorporate this feature."[19] Neither WISPA nor WSA ever

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17 *See* Part 15 Order at 9663 ¶ 276; Comments of WhiteSpace Alliance at 7, 25, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) ("WSA Comments"); Comments of the Wireless Internet Service Providers Association at iv, 21-22, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) ("WISPA Comments").

18 WSA Comments at 7.

19 WISPA Comments at 22.

provided any technical detail on the idea of database pushes.[20] No other party addressed the issue.

Given that the record lacked any meaningful discussion of how database "pushes" to unlicensed devices would work in practice, it is no surprise that the Commission failed to identify the faulty assumptions underlying its "push" rule. Now that the relevant facts are on the record, the Commission should reconsider its flawed requirement.[21]

C. The Commission should instead adopt "fast-polling" channels.

Rather than requiring every unlicensed device to query a database every 20 minutes, or—worse still—requiring a database to "push" information to unlicensed devices, the Commission can protect licensed wireless microphone use in breaking news situations by identifying two "fast-polling" channels as proposed by Google and supported by other commenters, including

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[20] *See, e.g.* Reply Comments of the Wireless Internet Service Providers Association at 21, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 25, 2015) ("As a better alternative to database re-checks every twenty minutes, WISPA agrees with WSA that the Commission could instead require the database to 'push' information about wireless microphone use to the white space device. As WSA states, such a requirement 'would be far more efficient' and eliminate the need to increase the frequency of database re-checks." (citing WSA Comments at 7, 25) (footnotes omitted)); Letter from Stephen E. Coran, Counsel to WISPA, to Marlene H. Dortch, Secretary, Federal Communications Commission at 2, ET Docket No. 14-165, GN Docket No. 12-268, RM-11745 (filed June 18, 2015) ("As alternatives [to the 20-minute recheck requirement], WISPA suggested that the Commission might require databases to 'push' information about wireless microphone use to white space devices if a frequency change is required.").

[21] *See Qwest Corp. v. Fed. Commc'ns Comm'n*, 258 F.3d 1191, 1202 (10th Cir. 2001) (reversing and remanding an FCC high-cost universal service support order, in part because the FCC acted without adequate record support, stating "[t]he FCC is not a mediator whose job is to . . . come to a 'reasonable compromise' among competing positions. As an expert agency, its job is to make rational and informed decisions on the record before it in order to achieve the principles set by Congress"); *California v. Fed. Commc'ns Comm'n*, 905 F.2d 1217, 1233-38 (9th Cir. 1990) (finding a Commission decision arbitrary and capricious where the decision lacked adequate record support).

the Wi-Fi Alliance.[22] On just these two channels, unlicensed devices would be required to query the database every 20 minutes to check for wireless microphone reservations that must be quickly accommodated,[23] while allowing the majority of unlicensed devices operating on other channels to continue to check the database daily.

This approach would allow broadcasters and other licensed wireless microphone users covering breaking news events to register on a fast-polling channel with the guarantee that all unlicensed devices will clear the channel within 30 minutes and leave it clear and available for microphone use.[24] At the same time, unlicensed devices could be programmed to operate on a fast-polling channel only when the associated requirements are worth the extra burdens—such as to maintain a desired level of performance in areas where spectrum is scarce—and otherwise operate exclusively on daily-polling channels. Designating specific fast-polling channels thus would minimize the burden of constant rechecking on unlicensed devices and database operators, while still providing adequate protection for wireless microphone use during breaking news events.

In the Part 15 Order, the Commission gave two reasons for not designating specific fast-polling channels. First, the Commission expressed concern that it would not be able to "determine until after the post-auction transition period which vacant channels will be available for wireless microphones and white space devices in any given area."[25] This concern

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[22] Google Comments at 47-51; Comments of Anant Sahai at 3, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Dec. 10, 2014); *see also* Letter from Russell H. Fox, Counsel to Wi-Fi Alliance, to Marlene H. Dortch, Secretary, Federal Communications Commission at 4, ET Docket No. 14-165 (filed Apr. 14, 2015).

[23] Google Comments at 47-51.

[24] *Id.* at 48-49.

[25] Part 15 Order at 9663 ¶ 277.

misunderstands the fast-polling channel proposal. Although it would be simple and convenient to designate the same two channels for fast-polling nationwide, market variations will likely make this infeasible. For this reason, Google proposed in its comments that the Commission identify fast-polling channels in each market using a simple and consistent set of rules to allow microphone operators and white space devices to identify the fast-polling channels.[26] Much as today's Part 15 rules identify the first available channels above and below channel 37 in a particular market for use by wireless microphones, the new, post-auction white space rules could identify, for example, the lowest two available UHF channels for fast polling. Even though the lowest two available UHF channels would vary with location, devices will always be able to identify the fast-polling channels by identifying the lowest available UHF channels at that time and in the location where they are operating. There would be no need for the Commission to specifically identify these channels—it need only announce a rule that can be applied to identify these channels at any given time and place.

Second, the Commission stated that restricting the number of fast-polling channels "is less flexible in meeting the needs of wireless microphone users for immediate access to spectrum."[27] The Commission cited the Reply Comments of the National Association of Broadcasters ("NAB"), which argued that some breaking news events may draw "news crews from distant areas with equipment that operates on channels different from those specified for 'fast polling' in a particular area."[28] But NAB's argument is unfounded. Wireless microphones

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[26] Google Comments at 50.

[27] Part 15 Order at 9664 ¶ 277.

[28] Reply Comments of the National Association of Broadcasters at 7, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 25, 2015).

are capable of tuning to white spaces across a wide range of channels.[29] Wireless microphone operators and manufacturers must already be able to cope with variability in available channels as a fundamental reality of operations in the television bands today. After the incentive auction, regardless of the approach the Commission takes to rapidly clearing channels for electronic newsgathering ("ENG"), the channels available for use by wireless microphones will vary by market. The Commission should therefore reject NAB's factually unfounded argument and find that fast-polling channels best suit the needs of both the unlicensed community and licensed wireless ENG microphone users.

III. THE COMMISSION SHOULD CLARIFY THE ROLE OF CHANNEL 37 TEST DEPLOYMENTS AND ESTABLISH A RECOMMENDED TARGET DATE BY WHICH IT WILL ALLOW NATIONWIDE UNLICENSED OPERATIONS IN CHANNEL 37.

The Part 15 Order set forth highly conservative operating rules for unlicensed devices operating in Channel 37 that will more than adequately protect Wireless Medical Telemetry Service ("WMTS") incumbents.[30] The Commission could have protected WMTS users, with a margin of safety, while still allowing productive use of unlicensed devices closer to hospitals.[31]

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[29] *See, e.g.*, Shure, *Shure FP Wireless User Guide* at 6, 9-12 (2012), http://www.shure.eu/dms/shure/products/wireless/user_guides/fp_wireless_user_guide_EN_1759kB/fp_wireless_user_guide_EN_1759kB.pdf (last visited Dec. 22, 2015) (showing a variety of frequency ranges where wireless microphone advertised for electronic news gathering can operate); Sennheiser, *ew 100 ENG G3*, Technical Data, http://en-us.sennheiser.com/wireless-clip-on-lavalier-microphone-set-presentation-ew-100-eng-g3 (last visited Dec. 22, 2015) (same); Sennheiser, *ew 135-p G3-A, Technical Data*, http://en-us.sennheiser.com/wireless-microphone-vocal-voice-interviews-reporting-ew-135-p-g3 (last visited Dec. 22, 2015) (same).

[30] *See, e.g.*, Part 15 Order at 9633 ¶ 198, 9639-41 ¶¶ 211-15, 9643-44 ¶¶ 220-21.

[31] *See* Letter from Paul Margie, Counsel for Google Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission at Attachment at 11-12, GN Docket No. 12-268 and ET Docket No. 14-165 (filed June 11, 2015); Letter from Aparna Sridhar, Counsel, Google Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission at 8-11, ET Docket No. 14-165 and GN Docket No. 12-268 (filed May 22, 2015); Letter from Paul Margie, Counsel for Google Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission at 2 and Attachment at 5, GN Docket No. 12-268 and ET Docket No. 14-165

In addition, the Commission created a waiver process by which WMTS operators might as much as *triple* the applicable separation distance for white space devices.[32] And yet, even while adopting these excessively restrictive rules for unlicensed use of Channel 37, the Commission created still more uncertainty for the unlicensed industry by stating that it intends first to limit test deployments of unlicensed services in Channel 37 to only one or two markets before authorizing nationwide roll-out.[33]

Such uncertainty will undermine investment in the development of unlicensed equipment for use in the 600 MHz and repurposed television bands, and slow unlicensed network deployments. To foster certainty and stability, the Commission should therefore: (1) clarify that it will consider test deployment requests even before the deadline for health care facility registration has passed;[34] (2) clarify that the Commission will consider reducing the generally applicable separation distances adopted in the Part 15 Order if test deployments indicate that reducing the separation distances will not cause harmful interference to WMTS, and that test deployments will not delay nationwide roll-out of unlicensed services in Channel 37 under the existing rules, and (3) establish a date by which it intends to authorize nationwide deployment of unlicensed services in Channel 37. Unless the Commission clarifies the purpose and timing for

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(filed Mar. 24, 2015); Reply Comments of Google Inc. at 12-17, 24, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 25, 2015); Reply Comments of Microsoft Corporation at 16-22, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 25, 2015); Comments of Broadcom Corporation at 22-25, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015); Google Comments at 18-22, 31-35; Comments of Microsoft Corporation at 19-25, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015).

[32] Part 15 Order at 9642-43 ¶ 217 & n.554.

[33] *Id.* at 9643-44 ¶ 221.

[34] *See id.* at 9643-44 ¶ 221 n.560.

the proposed test deployments and offers a target date for nationwide roll-out, this test deployment process has the potential to negate the positive step on Channel 37 that the Commission took in the Part 15 Order.

In order to create clarity for the unlicensed and WMTS industries alike, the Commission should therefore provide additional guidance regarding the role of and timeline for approving Channel 37 test deployments. The Commission indicated in a footnote that it would accept unlicensed deployment proposals even before the deadline for health care facility registration has passed.[35] The Commission should affirm that it intends to accept such deployment proposals immediately upon the effective date of the substantive rules adopted in the Part 15 Order (thirty days after publication of the Part 15 Order in the Federal Register), whether or not the new information collection for WMTS facilities has been approved by the Office of Management and Budget or whether all healthcare facilities have registered.[36] Because test deployments will be carried out in direct collaboration with nearby WMTS facilities, there is no need to wait for the nationwide registration process before beginning them. The Commission should also clarify that it intends expeditiously to consider such test deployment proposals.

Second, the Commission should clarify that it will consider reducing the standard separation distances and other mitigation measures adopted in the Part 15 Order if test deployments indicate that this can be accomplished without risking harmful interference to WMTS. As noted above, the Commission adopted in the Part 15 Order a belt-and-suspenders

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[35] *Id.* at 9643-44 ¶ 221 n.560.

[36] *Id.* at 9668 ¶¶ 295 (establishing an effective date of thirty days after Federal Register publication for most rule changes adopted in the Part 15 Order, but noting that changes to Section 95.1111(d) of the Commission's rules relating to WMTS facility registration is subject to OMB review under the Paperwork Reduction Act).

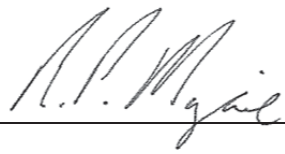
approach to unlicensed use of Channel 37, and it is likely that test deployments will show the Commission's Part 15 rules to over- rather than under-protect WMTS.

Finally, in order to provide unlicensed investors, equipment manufacturers, and network operators the certainty they need to move forward with white space deployments, the Commission should also establish a recommended target date for nationwide commencement of Channel 37 operations. The test deployments described above should not delay nationwide roll-out of unlicensed operations. In the usual manner of incumbent users, WMTS advocates have consistently opposed expanded unlicensed use of Channel 37 and resisted reasonable sharing approaches. If WMTS licensees similarly do not engage in cooperative testing in an expeditious manner, that should not prevent the Commission from moving forward with nationwide authorization of unlicensed operations in Channel 37. Establishing a target date for nationwide roll-out will provide certainty for unlicensed innovators and investors and encourage all parties to participate cooperatively in the testing process.

IV. CONCLUSION.

For the foregoing reasons, Google respectfully requests that the Commission (1) recognize that its decision to require databases to "push" information to unlicensed devices was based on insufficient record evidence and incorrect assumptions, and instead adopt a channel-specific fast-polling channel approach and (2) clarify the procedures for Channel 37 test deployments as described in this Petition, and establish a target date for nationwide roll-out of unlicensed operations in Channel 37.

Respectfully submitted,



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December 23, 2015

ATTACHMENT A

DECLARATION OF ANDY LEE

Before the
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Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions	)	GN Docket No. 12-268

DECLARATION OF ANDY LEE

1. My name is Andy Lee. I am the technical lead for the Spectrum Database program at Google Inc. ("Google"). Before joining Google, I founded TV Fool LLC (TV Fool), an industry-leading website providing spectrum analysis tools and other resources for analyzing the strength and availability of over-the-air broadcast transmissions. Prior to TV Fool, I worked for several years on wireless issues for the digital television, cellular, GPS, consumer electronics, and aerospace industries. I have a B.S. degree in electrical engineering from the University of California, Los Angeles, and a M.S. degree in Computer Engineering from the University of Southern California.

2. I have reviewed the Report and Order ("Part 15 Order") in the above-captioned proceedings, including the relevant portions addressing a new requirement that white-space databases "push" information regarding wireless microphone reservations to unlicensed white-space devices. I understand this rule to contemplate that white-space databases will send information to white-space devices whose operations may be affected by new wireless microphone reservations, without the white-space device having to request that information. I further understand that the Federal Communications Commission ("FCC") intended this requirement as a less burdensome alternative to having white-space devices "pull" information from (that is, query) white-space databases.

3. In fact, requiring a database to push information to white-space devices imposes similar or greater burdens on white-space devices and databases than requiring white-space devices to pull information from the database every 20 minutes. This is because, as explained below, the pull model is already established in Internet networking, to the exclusion of the push model, and so, in practice, the FCC's push mandate would have to be implemented through work-arounds that utilize the pull approach. The push approach, therefore, is even less efficient than the unacceptably inefficient pull approach.

4. Most Internet communications follow a request/response model. This means that instead of maintaining long-lived, open connections, Internet client devices and software send a request to a specified address, receive a response, and terminate the connection. Most Internet infrastructure, including

firewalls and home routers, is designed under the assumption that the large majority of communications will adhere to the request/response model.

5. Most firewalls and routers operate consistent with the assumption that devices will receive information only after requesting it. For example, it is common for unlicensed devices of all types to connect to the Internet through one or more firewalls, a router using network address translation ("NAT") (a technology used to allow public Internet access to and from devices with non-routable IP addresses), or other network systems designed to block incoming connections. Like other incoming connections, pushed messages from white-space databases are likely to be blocked. Firewalls and home routers using NAT are able to know which incoming data is a desired response to a user request by monitoring outgoing requests, assigning each outgoing request to a "port" and then permitting a single response to that same port from the IP address to which the initial request was sent.

6. White-space database administrators have no control over these systems and cannot configure them in a way that could accommodate messages pushed from the database to white-space devices. End users typically will not have the authority or technical expertise to make the necessary changes to these systems either and, in any event, doing so could introduce significant security vulnerabilities into the user's network.

7. Most systems that give the appearance of push capabilities are actually "pull" systems. Devices simply pull the desired information very

frequently. In such cases, the lag time between the data becoming available and its appearance on the user's device is sufficiently small to give the illusion of immediacy.

8. Implementing a push system in this way would be at least as resource-intensive for devices and database administrators as a 20-minute database polling interval. It would impose significant penalties on user devices in the form of reduced battery life, and on database administrators in the form of dramatically increased database server utilization (which, in turn, may drive a corresponding database fee increase for device manufacturers and fixed device registrants). Under this approach to implementing database push, ensuring that database updates will be transmitted to the necessary white-space devices within 20 minutes will require "pull" requests no less often than every 20 minutes. For any additional desired decrease in response time, there would need to be a corresponding increase in how often each device pulls information from the database.

9. In an extreme approach to implementing a supposed "push" system, the user's device establishes and maintains a persistent connection to the server that will be pushing the information. This achieves "true" push functionality in the sense that updates are transmitted immediately without waiting for a client device to request the information. However, this approach is functionally similar to constant pulling, and results in even greater resource consumption—for both the white-space device and white-space database

operator—than the ordinary pull approach. Moreover, some network environments will not support a persistent connection.

10. Maintaining a persistent connection typically involves a client device sending a request to the server without the server sending an immediate response. This will cause routers, firewalls, and most other network systems between the client device and server to not immediately close the port it opens in anticipation of a response from the server. So long as this port remains open, it will be possible for the server to use it to send a message to the client.

11. However, it requires nearly constant activity to keep such a connection open. Most systems are designed to wait only a small period of time before a router or firewall, for example, will close any port it has held open in anticipation of a message from the server. To prevent this "timeout," a client must send "keep-alive" messages, which serve no function except to signal that the connection may still be in use and should not be closed.

12. To verify that the connection remains open, the server must also send periodic "heartbeat" messages to the client. If the client has not received a heartbeat message in a specified period of time, it will attempt to reestablish the persistent connection. These heartbeat messages must be sufficiently frequent to ensure that a broken connection is detected and remedied quickly enough to promptly receive and act upon any message from the database.

13. Heartbeat messages may be very infrequent or dispensed with entirely in consumer applications, such as smartphone push notifications, where

it is acceptable for some notifications to be delayed or missed entirely. But for time-sensitive systems such as the white-space databases, these messages would need to be exchanged frequently to achieve the necessary level of responsiveness and reliability using a persistent connection.

14. Similar to a standard pull approach, sending and exchanging periodic keep-alive and heartbeat messages consumes a significant amount of power on the client device, and consumes significant server resources for database administrators. In addition, under the persistent connection approach a white-space device never could go into a low-power-consumption 'sleep' mode, because doing so would cause the persistent connection to terminate.

15. Furthermore, many routers and firewalls have only a limited number of ports that they are able to leave open for the purpose of facilitating persistent connections. Widely deployed white-space devices, each with its own persistent connection to a white-space database, would likely exhaust the number of available ports in many network environments resulting in network instability. Similarly, proxies or virtual private networks ("VPNs") may refuse new connections if they run out of resources, making persistent connections impossible.

16. As noted above, either approach to facilitating push updates has substantially the same operational difficulties as a standard pull implementation, but to an even greater degree, and results in substantially increased power consumption. This would likely make it impossible to deploy long-lived, battery-

powered white-space devices. Using white-space technologies to deploy, for example, battery-powered smart meters, security monitors, or other remote sensors may not be technically feasible.

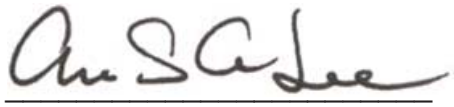
17. Both approaches would also impose significant additional costs on database operators. They would be required to either respond to frequent "pull" requests from white-space devices, or to maintain persistent open connections to millions of devices simultaneously, pushing server and network resources to their limits. These demands would radically change the economics of operating a white-space database, likely necessitating increased database management fees.

18. These burdens would be equivalent to or greater than the burdens associated with requiring a device to query the database every 20 minutes.

19. Limiting the geographic scope for these push messages would provide no relief from these burdens. Even if databases are only required to push wireless microphone reservation information to devices in a limited geographic area surrounding a location where microphones will be operating, all white-space devices everywhere will still have to check with the database frequently, or maintain a persistent connection, to ensure that they receive such notifications when and if the device is within a covered area.

* * *

I, Andy Lee, declare under penalty of perjury that the foregoing declaration is true and correct. Executed on December 23, 2015.



Andy Lee